

What is Claimed is:

1 1. A steerable diagnostic catheter comprising:
2 a catheter body having a proximal end portion and a distal end
3 portion including a probe assembly formed by
4 a deformable length of multi-lumened tubing having a first end and a second
5 end, said first end being affixed to said proximal end portion of said catheter body,
6 an end cap affixed to said second end, and
7 a plurality of electrodes distributed along the length of said tubing, said
8 electrodes being formed by metal rings circumscribing said tubing and disposed in
9 spaced apart relationship along the length thereof ;
10 a handle affixed to said proximal end portion, and including a steering actuator;
11 a plurality of signal wires extending through said handle, said proximal end portion
12 and the lumens of said tubing, a distal end portion of each said signal wire being deformed
13 and extending through an opening in the wall of said tubing, said deformed portion being
14 ohmically connected to one of said rings by mechanical engagement thereto;
15 at least one steering wire having a first end affixed to said steering actuator and
16 extending therefrom through said proximal end portion and a lumen of said tubing, said
17 steering wire being affixed to said first end of said tubing;
18 whereby manipulation of said steering actuator causes said probe assembly to be
19 deformed thereby enabling said catheter to be steered.

1 2. A steerable diagnostic catheter as recited in claim 1 wherein said steering actuator
2 is pivotably mounted to said handle.

1 3. A steerable diagnostic catheter as recited in claim 1 wherein said steering actuator
2 is pivotably mounted within said handle, and extends out of said handle through a slot
3 provided therein so that said steering actuator can be moved about a pivot.

1 4. A steerable diagnostic catheter as recited in claim 2 wherein said steering wire is
2 formed by a single length of wire having a first end connected to said steering actuator on one
3 side of said pivot, extending through said proximal end portion and a lumen of said tubing to
4 said second end where it engages said tubing, back through a lumen of said tubing, and back
5 through said proximal end portion to said handle, the second end of said steering wire being

6 attached to said actuator on an opposite side of said pivot, whereby movement of said
7 actuator in one direction causes deflection of said distal end portion in one direction and
8 movement of said actuator in an opposite direction causes deflection of said distal end portion
9 in another direction.

1 5. A steerable diagnostic catheter as recited in claim 4 wherein said end cap includes
2 a projection that extends into and mates with a lumen of said tubing, said projection having a
3 transverse opening therein through which said steering wire extends.

1 6. A steerable diagnostic catheter as recited in claim 5 wherein said steering wire
2 passes through a single lumen of said tubing and wherein a guide means is provided in said
3 lumen proximate said first end.

1 7. A steerable diagnostic catheter as recited in claim 1 wherein said mechanical
2 engagement of said ring to said signal wire is facilitated by a short length of wire partially
3 wrapped about said tubing, passing beneath said deformed portion and lying between said
4 ring and said tubing.

1 8. A steerable diagnostic catheter as recited in claim 1 wherein said mechanical
2 engagement of said ring to said signal wire is achieved by folding said deformed portion back
3 upon itself such that interference of the folded portion with the deformed portion maintains
4 mechanical engagement of said folded portion to said ring.

1 9. A steerable diagnostic catheter as recited in claim 2 wherein said steering wire is
2 formed by a single length of wire having a first end connected to said steering actuator on one
3 side of said pivot point, said steering wire extending through said proximal end portion and a
4 first lumen of said tubing to engage said second end of said tubing, extending back through a
5 second lumen of said tubing, and back through said proximal end portion to said handle, the
6 second end of said steering wire being attached to said actuator on an opposite side of said
7 pivot point, whereby movement of said actuator in one direction causes deflection of said
8 distal end portion in one direction and movement of said actuator in an opposite direction
9 causes deflection of said distal end portion in another direction.

1 10. A steerable diagnostic catheter as recited in claim 9 wherein said proximal end
2 portion includes tube means through which said steering wires are passed.

1 11. A steerable diagnostic catheter as recited in claim 10 wherein said tube means
2 includes a first tube having its proximal end affixed to said handle, a coil spring attached to
3 the distal end of said first tube, and second and third tubes having their proximal ends affixed
4 to the distal end of said coil spring, wherein said steering wire extends through said first,
5 second and third tubes.

1 12. A steerable diagnostic catheter as recited in claim 11 wherein said first and
2 second lumens have coil springs disposed therein, and wherein the proximal ends of said
3 springs respectively engage the distal ends of said first and second tubes, said steering wire
4 passing through said coil springs, said coil springs aiding in compression control of said
5 probe assembly.

1 13. A steerable diagnostic catheter as recited in claim 12 and wherein said probe
2 assembly further includes a C-shaped tube having one end engaging the distal end of one of
3 said coil springs and the other end engaging the distal end of the other of said coil springs,
4 said steering wire passing through said C-shaped tube.

1 14. A steerable diagnostic catheter as recited in claim 13 and wherein said
2 deformable length of multi-lumened tubing has a coaxially disposed lumen of generally
3 rectangular transverse cross section extending along its length, said transverse cross section
4 having a first dimension substantially longer than its orthogonal dimension, said first and
5 second lumens being disposed on opposite sides of said coaxially disposed lumen and lying
6 in a plane orthogonal to said first dimension, said coaxially disposed lumen tending to limit
7 the direction of deflection of said probe assembly to directions lying in said orthogonal plane.

1 15. A steerable diagnostic catheter as recited in claim 4 wherein said steering wire
2 has a generally D-shaped transverse cross section and extends through said probe assembly
3 with the flat face of the portion thereof extending through said first lumen facing the flat face
4 of the portion thereof extending through said second lumen.

1 16. A steerable diagnostic catheter as recited in claim 15 wherein said multi-lumened
2 tubing has a coaxially disposed lumen of oval transverse cross section and wherein said probe
3 assembly further includes a coil spring disposed within said coaxially disposed lumen.

1 17. A steerable diagnostic catheter as recited in claim 16 wherein the lumens
2 containing said signal wires are disposed in arcuate arrays on opposite sides of a plane
3 passing through said steering wires aiding in reduction of stresses on said signal wires during
4 deflection of said probe assembly.

1 18. A steerable diagnostic catheter as recited in claim 2 wherein said multi-lumened
2 tubing has first and second lumen disposed on opposite sides of its longitudinal axis, wherein
3 said probe assembly further includes an elongated resilient member disposed in said first
4 lumen, and wherein said steering wire passes through said second lumen and has its distal end
5 attached to the distal end of said resilient member.

1 19. A steerable diagnostic catheter as recited in claim 2 wherein said proximal end
2 portion has an internally disposed tube extending along the length thereof, and said multi-
3 lumened tubing has a coaxially disposed lumen, and wherein said probe assembly further
4 includes a coil spring having its proximal end engaging the distal end of said internally
5 disposed tube and a straightened segment of the coil wire at its distal end folded back to pass
6 through the interior of the coil spring to form said steering wire, the free end of said coil wire
7 extending back through said proximal end portion and into said handle where it is attached to
8 said actuator.

1 20. A steerable diagnostic catheter comprising:
2 an elongated, tubular central member having a distal end and a proximal end, said
3 central member having a deformable end portion proximate said distal end;
4 a catheter body having a proximal portion and a distal portion enveloping said central
5 member, said distal portion including a probe assembly formed by
6 a plurality of deformable lengths of multi-lumened tubing forming splines
7 disposed in parallel and surrounding relationship to the deformable end portion of said
8 central member, each said length of multi-lumened tubing having a first end affixed to
9 the distal end of said central member by an end cap, and a second end affixed to the
10 distal end of said proximal portion of said catheter body, and

11 a plurality of electrodes distributed along the length of each spline, said
12 electrodes being formed by circumscribing metal rings ;
13 a handle affixed to said proximal portion, and including a steering actuator and a
14 slider means for enabling relative axial movement between said proximal portion and said
15 central member;
16 a plurality of signal wires extending through said handle, said proximal portion and
17 the lumens of said splines, a distal end portion of each said signal wire being deformed and
18 extending through an opening in the outer wall of its corresponding tubing, said deformed
19 portion being ohmically connected to one of said rings by mechanical engagement thereto;
20 at least one steering wire having a first end affixed to said steering actuator and
21 extending therefrom through said central member and being affixed to the distal end;
22 whereby movement of said slider means causes deployment of said lengths of multi-
23 lumened tubing away from central member, and
24 whereby manipulation of said steering actuator causes deformation of said deformable
25 end portion and said probe assembly thereby enabling said catheter to be steered.

1 21. A steerable diagnostic catheter as recited in claim 20 wherein said each of the
2 spline forming tubes includes central lumen having a length of spring wire disposed therein to
3 provide conformal forces causing the splines to conform to the surfaces being inspected.

1 22. A steerable diagnostic catheter as recited in claim 20 wherein said steering
2 actuator is pivotably mounted to said handle.

1 23. A steerable diagnostic catheter as recited in claim 20 wherein said steering
2 actuator is pivotably mounted to said slider means.

1 24. A steerable diagnostic catheter as recited in claim 20 wherein said steering
2 actuator is pivotably mounted within said handle and extends through a slot formed therein.

1 25. A steerable diagnostic catheter as recited in claim 24 wherein said steering wire is
2 formed by a single length of wire having a first end connected to said steering actuator on one
3 side of said pivot, extending through said central member and to the distal end thereof where
4 it engages said central member , and then back through said central member to said handle
5 where a second end thereof is connected to said steering actuator on an opposite side of said

6 pivot, whereby movement of said steering actuator in one direction causes deflection of said
7 probe assembly in one direction and movement of said steering actuator in an opposite
8 direction causes deflection of said probe assembly in another direction.

1 26. A steerable diagnostic catheter as recited in claim 20 wherein said mechanical
2 engagement of said each ring to a corresponding signal wire is facilitated by a short length of
3 wire partially wrapped about the corresponding tubing, passing beneath said deformed
4 portion and lying between the ring and the tubing.

1 27. A steerable diagnostic catheter as recited in claim 20 wherein said mechanical
2 engagement of each said ring to a corresponding signal wire is achieved by folding said
3 deformed portion back upon itself such that interference of the folded portion with the
4 deformed portion maintains mechanical engagement of the folded portion to the ring.

1 28. A steerable diagnostic catheter as recited in claim 20 wherein said central
2 member includes a first tube having its proximal end affixed to said handle, a coil spring
3 attached to the distal end thereof, and second and third tubes having their proximal ends
4 affixed to the distal end of said coil spring, wherein said steering wire extends through said
5 first, second and third tubes.

1 29. A steerable diagnostic catheter as recited in claim 28 wherein said deformable
2 end portion of said central member is formed by a tube including first and second lumens
3 extending along the length thereof and having coil springs disposed therein, the proximal
4 ends of said first and second springs respectively engaging the distal ends of said first and
5 second tubes, said steering wire passing therethrough, said first and second coil springs
6 aiding in compression control of said probe assembly.

1 30. A steerable diagnostic catheter as recited in claim 29 wherein said probe
2 assembly further includes a C-shaped tube having one end engaging the distal end of said
3 first coil spring and the other end engaging the distal end of said second coil spring, said
4 steering wire passing through said C-shaped tube.

1 31. A steerable diagnostic catheter as recited in claim 29 wherein said deformable
2 end portion of said central member has a coaxially disposed lumen of generally rectangular

3 transverse cross section extending along its length, said transverse cross section having a first
4 dimension substantially longer than its orthogonal dimension, said first and second lumens
5 being disposed on opposite sides of said coaxially disposed lumen and lying in a plane
6 orthogonal to said first dimension, said coaxially disposed lumen tending to aid in the uni-
7 planer deflection of said probe assembly.

1 32. A steerable diagnostic catheter as recited in claim 20 wherein said deformable
2 end portion of said central member is formed by a tube including first and second lumens
3 extending along the length thereof and wherein said steering wire has a generally D-shaped
4 transverse cross section and extends through said central member with the flat face of the
5 portion thereof extending through said first lumen facing the flat face of the portion thereof
6 extending through said second lumen.

1 33. A steerable diagnostic catheter as recited in claim 32 wherein said deformable
2 end portion of said central member has a coaxially disposed lumen of oval transverse cross
3 section and wherein said probe assembly further includes a coil spring disposed within said
4 coaxially disposed lumen.

1 34. A steerable diagnostic catheter comprising:
2 a catheter body having a proximal portion and a distal portion, said distal portion
3 including a probe assembly formed by
4 a deformable length of multi-lumened tubing having a first end and a second
5 end, said first end being affixed to said proximal portion of said catheter body, said
6 deformable length of multi-lumened tubing including a coaxially disposed first lumen
7 of generally rectangular transverse cross section extending along the length of said
8 probe assembly, said transverse cross section having a first dimension substantially
9 longer than a second dimension orthogonal to said first dimension, and second and
10 third lumens disposed on opposite sides of said first lumen and lying in a plane
11 orthogonal to said first dimension, and
12 a plurality of electrodes distributed in spaced apart relationship along the
13 length said probe assembly, said electrodes being formed by metal rings
14 circumscribing said length of multi-lumened tubing;
15 a handle affixed to said proximal portion, and including a steering actuator pivotably
16 mounted thereto;

17 a plurality of signal wires extending through said handle, said proximal portion and
18 other lumens of said length of multi-lumened tubing, a distal end portion of each said signal
19 wire being deformed and extending outwardly through an opening in the wall of said tubing
20 where it is ohmically connected to one of said rings by mechanical engagement therewith;

21 a single length of steering wire having a first end connected to said steering actuator
22 on one side of its pivotal mount, said steering wire extending through said proximal portion ^{of}
23 said second lumen to engage said second end of said length of multi-lumened tubing, then
24 extending back through said third lumen of said length of multi-lumened tubing, and back
25 through said proximal portion to said handle, the second end of said steering wire being
26 attached to said actuator on an opposite side of its pivotal mount,
27 whereby movement of said actuator in one direction causes deflection of said probe assembly
28 in one direction, and movement of said actuator in an opposite direction causes deflection of
29 said probe assembly in a second direction, said first and second directions lying in said
30 orthogonal plane.